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FAO Fisheries Biology Synopsis No. 4
(Distribution restricted)

FB/60/S4
SAST - Milkfish

SYNOPSIS OF BIOLOGICAL DATA ON MILKFISH

Chanos chanos (Forskal), 1775

Prepared by
W. H. SCHUSTER
(formerly Fisheries Biologist, Fisheries Division, FAO, Rome)

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Rome, November 1960

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FAO Fisheries Biology Synopsis No. 4 FB/60/S4
(Distribution restricted) SAST 1, 22(2), 001, 01

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PURPOSE OF THIS SERIES

This is one of a series of synopses of biological data concerning species of aquatic organisms of economic importance. The primary purpose of this series is to make existing information readily available to fishery scientists, according to a standard pattern, and by so doing also to draw attention to gaps in knowledge. It is hoped that synopses in this series will be useful to scientists initiating investigations of the species concerned or of related ones; as a means of exchange of knowledge among those already working on the species, and as the basis for comparative study of fisheries resources.

The synopses are the output of a system for cumulative storage and retrieval of data on the biology of species and stocks, called Species and Stocks Thesaurus (SAST), maintained by the Fisheries Biology Branch of FAO. They will be brought up to date from time to time, as further information becomes available. It is, therefore, recommended that they be filed in loose-leaf folders; pagination begins anew with each chapter, so that partial revisions may be made.

Biology Branch is working to secure the cooperation of scientists in drafting synopses on species about which they have special knowledge, and welcomes offers of help in this task. Additions and corrections to synopses already issued will also be most welcome. Comments and requests for information should be addressed to the editor of this series :

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PREPARATION OF THIS SYNOPSIS

Drafted initially to meet request from regional fisheries organisations - in this case for presentation to and discussion at the Eighth Session of the Indo-Pacific Fisheries Council (IPFC), 6-22 December, 1958 - a first draft was issued in 1958 as an FAO mimeo document and also as IPFC 8th Sess.Pap.(mimeo), IPFC/C58/WP25. This version was in 1959 reissued as IPFC Occasional Paper (59/3), and subsequently revised by the author on the basis of comments by the IPFC Chanos Sub-Committee.

The information given is derived from the sources listed in Chapter 6 and use has also been made of some unpublished information. The author and the editor wish to express their thanks especially to Dr. G.R. Fish, Chairman of the Chanos Sub-Committee for his valuable comments.

Distribution

Author
9th Session IPFC (Contributed Publication)
FAO Fisheries Division
FAO Regional Fisheries Officers
UNESCO
Fisheries workers concerned with this species
General distribution list, SAST Synopses

"Current Bibliography" entry

Schuster, W.H. (1960) 61-00570 MF
Rome, FAO, FB/60/S4
Synopsis of biological data on
milkfish Chanos chanos (Forskal), 1775

NE 59-7340. 1st revision of SAST
Synopsis.

Project No.
2.21

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1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

Phylum VERTEBRATA
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Malacopterygii
Suborder Clupeoidei
Family Chanidae
Genus Chanos Lacépède 1803
Species Chanos chanos (Forskal), 1775

1.1.2 Description

- Genus Chanos Lacépède 1803

"Body elongate, moderately compressed and pointed at both ends, with a broad rounded abdomen; head naked, with a large transparent imperforate adipose eyelid covering eye and side of head; trunk covered with firm, closely adherent, relatively small or medium-sized silvery scales; dorsal and anal each with a broad basal sheath; pectoral with a pointed axillary scale above; small scales extend upon the caudal; snout depressed; mouth small, terminal, transverse and toothless; lower jaw slightly included, with a symphysial tubercle, which fits into a notch in the upper jaw between the premaxillaries; the maxillaries short and broad with no supplemental bone; premaxillary joined at the upper anterior edge of maxillary; ventrals well developed, opposite the anterior half of the dorsal; the anal very much smaller than dorsal and placed very far back; caudal large, deeply forked; lateral line straight, each scale with a single tube; gill membranes entirely united below and free from the isthmus; four long branchiostegals; pseudobranchiae well developed; gillrakers exceedingly fine, numerous and close set in two diverging rows; an accessory branchial organ in a cavity behind the gill cavity proper; air bladder divided by a constriction into an anterior and posterior portion; mucus membrane of the oesophagus raised into a spiral fold; pyloric appendages numerous, intestine very long and with many convolutions, the peritoneum black." (Herre and Mendoza, 1929).

- Chanos chanos (Forskal) 1775

"Body elongate, compressed, thicker with age; head and anterior part of trunk much broader proportionally and head relatively shorter in large, old specimens; depth 3.5 to 3.75 in length; head 3.5 to 3.8 in length, equal to or less than depth; snout broad, usually about 3/4 in eye, 4.1 to 4.55 in head; eye large, 2.75 to 3.5 in head, usually 3.25 to 3.5; in young the broad flat interorbital equals the eye; in mature or large specimens it becomes rounded

and is a fourth or nearly half again as broad as the length of the eye; maxillary broad, slipping under the adipose preorbital, without a supplemental bone; dorsal nearer base of caudal than tip of snout; dorsal with a large scaly basal sheath which is elongated posteriorly, the anterior falcate ray 1.32 to 1.42 in head, the last ray produced in a short filament; the anal resembles the dorsal but is very much smaller, its height 3.36 to 5.9 times in head; the least depth of the powerful caudal peduncle is 2.7 to 2.85 times in the head in young, 3.3 times in adult or nearly mature specimens; the caudal is very large and deeply forked, the upper lobe slightly larger; 2.44 to 2.88 times in the length, not forked to the base as stated by some authors; the pointed pectoral is 1.85 to about 1.6 times in the head; the pointed axillary scale above 1.5 to 2 times in the pectoral, the axillary scale below much shorter; the ventral is 1.85 to 2.15 times in the head, its pointed axillary scale about 1.8 times in its own length; below each ventral is a very wide pointed scale.

"The colour in life is brilliant silvery over all, brilliant glossy blue or bluish olive above; the top of the head is yellowish olive, the sides whitish, the under side of the head white; the side of the head with golden glints and opalescent luster; golden luster also along sides on some specimens; dorsal more or less yellowish, and yellowish along the mid-line of the back behind the dorsal; the fins colorless or the pectorals, ventrals and anal more or less yellow; the caudal grey or colorless with a blackish posterior margin, or the lower lobe yellowish; some specimens have the inside of the pectorals and ventrals dusky to black.

"Adult Chanos are from about three-fourth of a metre to a metre and a half in length, exclusive the caudal fin. Specimens of this size differ much from the young in the shape of the top of the head and the anterior portion of the body. Sometimes specimens a metre or more in length are bulkier in proportion and at the shoulder girdle may be as large as a man's thigh. The top of the head is flat in the young and becomes convex in the adult." (Herre and Mendoza, 1929). (Fig. 1).

The characteristics of the alimentary tract of Chanos are given by Bridge and Boulanger (1910). The oesophagus, before making a real U-shaped bend in the gizzard section, follows a complete S-shaped curve. The interior surface of this part of the oesophagus displays parallel spiral folds and a great number of backward directed papillae. The lower part of the oesophagus is equipped with longitudinal folds, dwindling at the beginning of the gizzard, the so-called "stomach" of Chanos. The powerfully developed gizzard, identical to the pyloric part of the stomach of other Teleosts, is characteristic of the species.

For meristic characteristics see 1.3.1 - Meristic counts.

1.2 Nomenclature

1.2.1 Valid scientific name(s)

Chanos chanos (Forskal)

1.2.2 Synonymy

Mugil chanos Forskal 1775

Mugile chani Bonnaterre 1788

Mugil salmoneus Bloch and Schneider 1801

Chanos arabicus Lacépède

Lutodeira indica van Hasselt 1823

Lutodeira chanos Rupell 1828

Cyprinus (Leuciscus) palah. Cuvier 1829

Leuciscus ceylonicus Bennet 1882

Leuciscus (Ptycholepsis) salmoneus Richardson 1843

Chanos mento Cuvier and Valenciennes 1865

Chanos lubina Cuvier and Valenciennes 1846

Chanos chloropterus Cuvier and Valenciennes 1845

Chanos nuchalis Cuvier and Valenciennes 1846

Chanos orientalis Cuvier and Valenciennes 1846

Chanos cyprinella Cuvier and Valenciennes 1846

Chanos salmoneus Cuvier and Valenciennes 1846

Lutodeira salmonea Richardson 1848

Butirinus argenteus Jerdon 1849

Chanos pala Cantor 1849

Chanos indicus Bleeker 1859

Chanos (Lutodeira) chanos Günther 1866

Lutodeira chloropterus Playfair 1867

Fig. 1 Chanos chanos (Forskal)

1.2.3 Standard common names, vernacular names

Table I

COMMON AND VERNACULAR NAMES

Country	Standard Common Name	Vernacular Name(s)
Australia	Salmon herring	White mullet
Ceylon	Hyder's fish	Vaikka, Pal meen
Fiji	Yawa	Awa, Luya
Hawaiian Islands	Milkfish	Awa, awa awa, Awa kalamoku, Puawa
India	Milkfish	Tullu caudal, Palai meen, Pala kendai, Palmeen, Tullu-kendai, Paalabonta, Tullu, Poomeen, Hoomeenu
Indonesia	Bandeng	Banding, Bandang, Bolu, Baulu
Japan	Sabahii	
Malaya	Bandang	Jangas
Mexico	Sabalo	Sabalote
North Borneo (Br.)	Milkfish	Belanak sembawa
Philippines	Bangos	Awa, Banglis, Banglot, Bangris, Betel, Bangilis, Banglus, Bangros, Laon, Lumulokso, Sabalo
Saudi Arabia and Muscat Coast		Anged, Anget
Society Islands		Ava, Awa
Taiwan (Formosa)		Sabahi, Sard bark hi, Moa sard bark
Thailand	Pla nuanchan	Nuan chan tale, Chalin, Tu nam cut, Dok mai
USA	Milkfish	
Vietnam		Ca mang, Camoi dung

These names are commonly applied to fish from 200 to 500 mm length. Fry, young (fingerlings) and adult fish are often indicated by special group names.

1.3 General variability

1.3.1 Subspecific fragmentation (races, varieties, hybrids)

- Meristic counts

Meristic counts, shown below, have been given by several authors.

Table II

MERISTIC COUNTS OF *Chanos chanos*

Organs	United Kingdom Günther (1868) 1/	Netherlands Weber and De Beaufort (1913) 2/	Indonesia Sunier (1922)	Philippines Herre (1929)
Dorsal fin	14 - 16	14 - 16	14 - 16	II 12 or 14
Pectoral fins		16 - 17	16 - 17	I 15 or 16
Ventral fins	11 - 12	11 - 12	11 - 12	I 10 or 11
Anal fin	10 - 11	10 - 11	10 - 11	II 8 or 9
Lateral line	85 - 88	75 - 80	83 - 90	75 - 85 plus 5 - 7 on caudal base
Vertebrae	44		44 - 45	28 + 18 = 46
Branchiostegals		4		4

1/ Specimens from India.
2/ Specimens from Indonesia.

- Varieties

There are several reports about specimens deviating markedly from normally shaped fish. The aberration from the standard type is caused by a restriction of the growth in the direction of the longitudinal axis of the body. Such 'short' specimens have a length-height coefficient of 1.6 to 2.2 against one of four of the standard type. The number of vertebrae is the same in both types. 'Short' specimens have been reported from Java, Hawaii and New South Wales (Sunier, 1922). Nothing is known about the genetic features of the phenomenon.

A type with a distinct prolongation of the dorsal and pectoral fins, and a caudal fin surpassing the total length of the fish, may also be a variety. Specimens of this type are more or less similar in appearance to fish of the veil-tail variety of the gold fish. Specimens with prolonged fins have been reported from Indonesia only.

Albinism, melanism or rubism have not yet been observed, notwithstanding the fact that cultivation in ponds has given opportunity for a close observation of large stocks. Neither have morphological peculiarities been observed, that would encourage the selection of particular morphological types. For variation in colouration see 1.1.1.

Hybridization or development of new varieties by cross-breeding and selection of individuals with desirable properties is impossible, because it has been impossible so far to propagate the fish in impounded waters. Natural hybridization has never been observed.

2 DISTRIBUTION

2.1 Delimitation of the total area of distribution and ecological characterization of this area

The occurrence of Chanos has been reported from the following areas : the Red Sea coast; the east coast of Africa, including Zanzibar and Madagascar; the Gulf of Aden; the southwest, south and west coasts of India; the coasts of Ceylon, Malaya, Thailand, Vietnam and Taiwan; the south coast of Japan; the waters between the islands of the Philippines and Indonesia; the coasts of Australia, New Zealand, New Guinea, Fiji and Samoa; the coasts of the Society, Gilbert, Lau, Tuamoto, and the Hawaiian Islands; the west coast of the United States (south of San Francisco), the Gulf of California and the coast of Mexico.

According to this information the geographical distribution of the species ranges from longitude 40° E of Gr. to about 100° W of Gr., and from latitude 30° - 40° N to 30° - 40° S. This area covers the tropic and subtropic sections of the Indian and Pacific Oceans (Fig. 2).

The waters within this range are characterized by a relative scarcity of plankton offshore. A significant development of phytoplankton occurs only in a narrow zone along the coast, often where the nutrient content of the seawater is increased by materials introduced by the run-off from fertile inland areas. Offshore, the pelagic and benthic algae diminish in quantity and give place to coarse zooplanktonic organisms, mainly copepods. The zooplanktonic assemblage does not reach maximum density in open sea, but at the outer margin of the coastal phytoplankton zone, as for instance in the Java Sea at a distance of 25-40 mi from the shore (Delsman and Hardenberg, 1934).

2.2 Differential distribution

Contradictory statements about the range of the species have been made by various ichthyologists.

Bleeker (1866) says 'in sea and fish ponds'; Weber and De Beaufort (1913) mention as habitat 'in sea and estuaries'; Sunier (1922) says that 'in connection with its food, the bandeng is most likely confined to the littoral region'; Herre and Mendoza (1929) state : 'The bangos is a fish of the open sea and a swift and powerful swimmer; it rarely approaches land or enters shallow water except during March, April and May'.

In fact, all catches of Chanos, those of tremendous quantities of larvae as well as the comparatively small annual catches of adult specimens, are made close to the shore or at least within the range of small fishing craft. High-sea catches have not yet been reported. The larval and junior stages are definitely confined to littoral waters (see 2.2), but seasonal changes of the habitat of the adult fish are still open to question. Examinations of the intestinal contents of the adult Chanos revealed benthic and phytoplanktonic organisms to be the main food. It is therefore possible, and even likely, that the permanent occurrence of the species is limited to zones with a more abundant production of phytoplankton, i.e. the littoral waters.

2.2.1. Areas occupied by eggs, larvae and other junior stages : annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons. Areas occupied by adult stages : seasonal and annual variations of these

- Eggs

Exact information is available from Indonesia and India on the geographical position of some of the waters into which eggs are shed.

Delsman (1929) reports the capture of Chanos eggs in plankton hauls in the Java Sea. The eggs, 14 in total, were encountered at three different locations at a distance of five to 17 nautical mi from the coast. The geographical position of the location was : lat. 6° 47' S., long. 188° 30' E. The very great number of unsuccessful plankton hauls which Delsman made during his intensive investigations shows that eggs occur in very restricted areas only. The locations where the eggs were encountered are all less than 35 km from beaches used for the commercial collection of fry.

Jacob et al. (1948), as quoted by Bromhall (1954), report finding Chanos eggs in the plankton of the Ennore backwater, Chingleput district, Madras State, India. They state : 'Even though eggs and larvae of Mugil spp. Chanos chanos ..... were available, those of mullets predominated in the plankton collections.' Bromhall continues : 'Ennore must be an especially favourable area ..... for not only mullet eggs have been found there in quantity, but also eggs of Chanos chanos, a fish whose life history has been the subject of many enquiries with, if anything, less success than that attending the Grey Mullet investigations.'

Chacko (1950) reported seasonal occurrence of Chanos eggs in the waters around Krusadai Island, situated at lat. 9° 14'N., long. 79° 12'E., in the Gulf of Manaar close to the coast of India. Chacko made plankton catches weekly from September 1940 to August 1943, encountering Chanos eggs in an annual period stretching from March to August.

Saanin (1954) instigated an enquiry among fishermen to obtain additional information on the geographical position of the spawning grounds of Chanos in the waters of Indonesia. The enquiry did not result in factual evidence, but revealed a consensus of opinion among many fishermen that Chanos spawns close to the coast in clear water of 20 to 30 fms depth.

No exact data are available about the location of the spawning grounds in Philippine waters. Herre and Mendoza (1929) say : 'Chanos seems to spawn in quiet shallow sandy bays where the fry are found along the shore in immense numbers.' Blanco and Villadolid (1939) state : 'Chanos chanos spawns in waters not far from sheltered bays, coves and gulfs.' However, there are no statements either about actual observation of mating or spawning, or on recovering eggs.

A comparison of these data leads to the conclusion that clarity of water, restricted depth and sandy or coral bottom, are prerequisites for spawning. It should be noted that occurrence of ova or fry has never been reported from shore areas affected by the afflux of silt from rivers. Enquiries confirmed the non-occurrence of ova, fry and juvenile Chanos in the vicinity of and in the deltas of Indus, Ganges, Irrawaddy, Mekong and the great delta-forming rivers of Sumatra, Java, and Borneo. Commercial fry fisheries everywhere end abruptly at locations where the character of the beach changes from sandy to muddy.

Fig. 2 World distribution of Chanos chanos

- Yolk sac stage

According to Delsman's (1929) rearing experiments, the yolk sac stage has a duration of two-and-a-half days. It is evident that during this pelagic stage the larvae remain in the vicinity where the eggs have hatched, unless carried away by a current. Delsman's experiments and the observation of very young larvae showed that individual locomotion is negligible.

- Larval stages

Chanos larvae shift slowly in the direction of the coast during a one to two weeks period after hatching. Judging by the grade of development of myotomes and fins, the youngest larvae occurring in shore waters should be about ten days old; later in the season two to three week old specimens may be caught, but it seems possible that these have been living in inshore waters for some days prior to capture. A ten day old larvae would have to cover a distance of one to three kilometres a day from a hatching place such as, for instance, reported by Delsman.

Evidence about the behaviour of the larvae in inshore waters can be obtained from observation and investigation of the commercial catches of Chanos fry. It is likely that the larvae remain for about four weeks in the vicinity of the coast entering bays, coves, creeks, swamps, backwaters and similar bodies of water provided they are under the influence of flood and ebb. Lotic environments seem to be attractive to some degree, since accumulation of fry has often been observed at places where the freshwater run-off of a small stream falls into the sea. Larvae may ascend streams for some distance and sometimes they reach waters already populated by large Chanos. Many incorrect reports about spawning of Chanos in freshwater have been based on the non-recognition of the seasonal migration of fry into waters having an assemblage of several year classes of Chanos.

Table III has been compiled from reports on the seasonal occurrence of larvae in shore waters.

- Young fish

Fish 50 - 120 mm in size can often be observed at locations where fry have been caught earlier in the season. Individuals exceeding a length of 120 mm, but shorter than 800 mm, are very seldom caught in open water seaward of the shore, although they may occur in backwaters or coastal lakes.

Reports of observation and capture of young Chanos in littoral waters are available from the countries shown in Table IV.

Most of the localities coincide with those mentioned in Table III, on the occurrence of fry fingerlings gradually superseding the larvae.

Saanin (1954) collected information on the occurrence of Chanos of 50 - 120 mm length, in estuary waters in Indonesia. He reported the capture of young Chanos in coastal swamps along the north coast of Central Java. A report from Sumatra concerns seasonal migration of young Chanos from estuaries or swamps out to the sea.

Table III

AREAS OF OCCURRENCE OF CHANOS FRY

Country	Shore areas
India	Gulf of Manaar Palk Bay (fry entering saline lagunes) Coromandel Coast (fry entering backwaters) Malabar Coast, southern section (fry ascending small streams)
Indonesia	
Sumatra	North Coast, between Kutaradja and Lhokseumave South Pagai islands;
Java	North coast, exclusive of the deltas of the great rivers South coast : Djember regency only
Madura	All coasts including those of the adjacent islands
Borneo	East, southeast and southwest coast, excluding the deltas of the great rivers (incidental reports only)
Celebes	South coast, Gulf of Mandar, Gulf of Bone West coast, Spermonde Islands, Sangir Talaud
Bali	North, southeast and southwest coast
Lombok	West and southeast coast
Sumbawa	North coast, Komodo
Timor	Bay of Kupang
Philippines	
Luzon	Northwest coast; south coast, Batangas and Balayan Bays
Cebu	
Panay	
Mindanao	Zamboanga, and Davao Province
Mindoro	
Marinduque	
Taiwan	Southeast and southwest coast
Thailand	Bay of Bangkok
Vietnam	Annam coast, from Songceau to Phanrang
Fiji	Coast near Nadi

Table IV

AREAS OF OCCURRENCE OF YOUNG CHANOS

Country	Shore areas
India	Gulf of Manaar and Palk Bay Coromandel coast Malabar coast (southern section)
Ceylon	West coast : Dutch Bay
Indonesia	
Sumatra	North coast (one location only)
Java	North coast (few locations only)
Celebes	South coast
Sumbawa	North and east coast
Hawaiian Islands	Oahu, Molokai
Fiji	Coast near Nadi

Movement of young Chanos into streams or rivers with turbid water has never been observed; even in rivers with clear water, in most cases young Chanos travel upstream for a short distance only. There is one known exception: prior to the construction of dams in South Celebes, Indonesia, young Chanos migrated upstream a distance of about 50 km to reach the Tempe Lakes. Herre and Mendoza (1929) reported Chanos of 600 - 700 mm length to be present in great numbers in Lakes Taal, Naujan and Boto in souther Luzon, Philippines. Chanos of about 500 mm length also occur in some coastal lakes and backwaters in India and Ceylon (Fig 3).

- Adults

We have evidence that adult Chanos stays in littoral waters at least part of the year. Reports show that schools of 20 to 100 individuals swim close to the coast with the dorsal fin sticking out above the water surface, an attitude typical for large Chanos, as shown from observation in ponds. Reports on observations of large Chanos in the sea are available from Java, Sumatra, Celebes, Luzon, and New Guinea.

Stray specimens of adult Chanos are seasonally caught in stationary traps or are harpooned in waters close to the coasts of Java, Sumatra, Celebes, and Luzon. Modest commercial catches with seines are reported from the Coromandel and Malabar coasts, India, and from the Gulf of Bone, Celebes, Indonesia. Large Chanos are caught by trawlers or longlining

Fig. 3 Areas of capture of juvenile stages of Chanos chanos in coastal waters

vessels operating from harbours in Taiwan, New South Wales, and New Zealand. Large Chanos are well-known to native fishermen in Fiji, Samoa, and the Society Islands.

2.3 Behaviouristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution

Temperature is the prime factor responsible for limiting the habitat of the species to the tropical and subtropical regions of the Indian and the Pacific Ocean. The temperature tolerance of Chanos has been established experimentally, and the reliability of the findings confirmed in areas close to the climatic barriers of the species.

Susceptibility to low temperature is a factor to be considered when Chanos is reared in areas N or S of latitude 20°. Chen (1952), reporting on experiments in Taiwan fish culture, states : 'Milkfish is sensitive to low temperature. It becomes sluggish when the temperature drops below 15 degree Celsius, becomes paralized at temperatures below 13 degree Celsius and dies at a temperature of about 12 degree ..... If the exposure to cold is prolonged it may die at temperatures higher than those mentioned.' These data explain why the occurrence of Chanos in the waters of southern Japan is restricted to the summer months only.

The upper limit of temperature tolerance is above that of most other marine species. When cultivated in unused salt fields, Chanos has been observed to stand temperatures of more than 40°C. Sunier (1922) observed Chanos in ponds with a water temperature of 37.1°C.

Another factor which seriously limits the general distribution of the species is susceptibility to predation. Judging from the amount of effort required to protect young Chanos against predation during cultivation in ponds, the rate of survival in open water should be extraordinarily small. Many piscivorous species are abundant in the waters in which ova and junior stages of Chanos have been reported.

Estuarine areas with turbid water with dominant populations of predaceous Percesoces, Perciformes, Apodes, and Gobioformes, provide a particularly unfavourable environment for Chanos. In an environment where the purely physical factors are already disadvantageous to Chanos, predation is likely to become an especially serious limiting factor. For details about predation see 3.1.8 and 3.2.1 - Parasites and predators.

It should be noted that the natural habitat of young Chanos - clear water beaches with sandy bottom - has a limited potential to produce the benthic algae known to be the basic food supply of the junior stages. In fact, such algae grow abundantly in shallow waters where the bottom materials consist mainly of organic silt and sedimented clay. Thus human intervention, as in the transplantation of fry from beach to pond, can result not only in multiplying the supply of natural food, but also in increasing the probable rate of predation to a level at which survival of Chanos fry can be ensured only by specific protection measures.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)

Chanos is heterosexual. No externally observable characters are known to distinguish males and females.

3.1.2 Maturity (age and size)

A serious limitation in maturity studies is the comparative rarity of mature specimens. Catches of adult fish are very sporadic and specimens with mature gonads become available for investigation only occasionally. The entire literature on Chanos contains comprehensive data on hardly more than five specimens, although informal reference to the occurrence of mature fish is made in a considerably greater number of cases.

Herre and Mendoza (1929) refer to the smallest mature female so far on record, a fish with a standard length of 750 mm and a total length of about 940 mm. Panikkar et al. (1952) give data on the largest known female, an individual with a total length of 1,240 mm. In the 1951 report of the Indian Council of Agricultural Research, Madras Rural Piscicultural Scheme, reference is made to a male specimen of 1,200 mm with gonads in an advanced state of development. The maximum size of mature fish may be considerably higher than those appearing from the data above because there are several references in literature to fish heavier in weight than these, the length of which has been measured. Sunier's fish had a weight of 11,900 g at a length of 1,120 mm (see Table VI), but Chen (1952) refers to fish weighing 30 lbs at 13,590g, and to one specimen weighing over 40 lbs at 17,620 g. Fishermen in Indonesia report catching Chanos of more than 30 katties or 18,600 g, which would correspond to a standard length of 1,500 mm as mentioned by Herre and Mendoza (1929) in the morphological description of the fish (see 1.1.1).

No information is available on the age of the investigated mature specimens, since a conclusion could not be drawn from otolith readings. Also, comparison with fish of known age, reared in ponds, is not conclusive because suppression of gonad development in pond fish retards the growth after the fourth year. The same phenomenon can be observed in Chanos that has voluntarily entered fresh or brackish water lakes : the fish remain sterile as long as they are landlocked and seem unable to reach the size of adult fish in sea. In apparent contradiction is a statement by Thomas (1881) : 'Acclimatized to water that is slightly brackish, it runs to 20 or 30 lbs'. Fish of that size may migrate into lakes like Pulikat or Chilka (see 3.1.7), but it is open to question whether they are able to grow to that size in brackish water. The longest fish so far reported from inland waters in Madras State weighed 3,620 g.

In all areas where Chanos culture is practiced fish farmers have reared fish for a number of years, experimenting to obtain eggs either by natural spawning or by stripping. All attempts have failed. After four years of rearing the fish usually reached a weight of 2,500 to 3,500 g, but the gonads remained undeveloped. Occasionally the gonads of five to six year old fish increase in size, but even at that stage they are still far from being mature. The roe of such fish weights about 15 g, whilst the roe of a mature fish from the sea weighs 900 to 1,500 gm.

3.1.3 Mating (monogamous, polygamous, promiscuous)

Chanos is polygamous. Schools of large Chanos, in prespawning behaviour or in the act of mating, have been observed during several spawning seasons playing tumultuously close to the surface in water from four to five metres depth. Such observations are reported from the coast north and south of Macassar, Celebes, Indonesia (Reijntjes, 1926).

3.1.4 Fertilization (internal, external)

External. The eggs are fertilized while they float in the surface layers after spawning.

3.1.5 Fecundity

Estimates of the number of eggs in the ovary, derived from the gonad weight, vary from three to 7.3 million. Specimens close to the maximum weight have not yet been found with eggs, so the maximum number of eggs in a specimen may be considerably greater.

The great fecundity of Chanos is manifested by the abundance of fry in suitable areas right up to the very periphery of the area of distribution. Intensive fishing operations along the coasts of South Taiwan provide precise information on the abundance of fry in a typical marginal zone, since North Taiwan is already beyond the range of occurrence of juvenile stages. Table V also provides information on the variability of abundance over the years from 1922 to 1951.

Table V

NUMBER OF CHANOS FRY CAPTURED IN TAIWAN 1922 TO 1951. Chen (1952)
(in millions)

Year	Fry captured	Year	Fry captured	Year	Fry captured
1922	20	1932	118	1942	41
1923	49	1933	114	1943 3/	8
1924	30	1934	24	1944	17
1925	31	1935	25	1945	25
1926	45	1936	26	1946	50
1927	14	1937	14	1947	43
1928	28	1938	73	1948	73
1929	24	1939	36	1949	77
1930	36	1940	36	1950	102
1931	95	1941	41	1951	30

3/ The low production in 1943 was due to war conditions.

- Relation of gonad size and egg number to body size and to age

Counts have been made of the ovarial eggs in three mature specimens. The first was caught in 1916 in coastal waters near Pasuruan, East Java, Indonesia; the second in 1919 near Djakarta, Indonesia; and the third in 1927 in Subic Bay, Luzon, Philippines. The relevant data as published by the investigators are compiled in the Table below.

Table VI

COUNTS OF OVARIAL EGGS IN THREE MATURE SPECIMENS

	Reijntjes (1923)	Sunier (1922)	Herre (1929)
Total length	820 mm	1,120 mm	940 mm
Weight	4,000 g	11,900 g	
Weight of the ovaries		1,304 g	900 g
No. of eggs in 1 g of roe		4,370 g	3,415
Total no. of eggs	4,200,000	5,700,000	3,060,000
No. of eggs per 1,000 g of body weight	1,050,000	478,000	

Herre and Mendoza (1929) say : 'An increase in the length of a fish means a far greater increase proportionally in its bulk. A bangos a metre and a quarter in length not counting the caudal fin is, perhaps, at least twice as large as one, three-fourth of a metre long. It seems probable that a bangos never contains less than a million and a half eggs, and that a very large female may have an excess of 7,000,000 eggs. Bangos average 3,000,000 and can only be exceeded, if at all, by the cod, which has been known to have about 9,000,000 eggs.'

3.1.6 Spawning

- Spawning seasons (beginning, end, peak)

The definite range of the spawning season has not yet been established, mainly because the exact location of the spawning grounds is known in only very few cases. However, the activities of thousands of fishermen who comb the shore waters in search of Chanos fry, make it possible to assess the range more or less accurately; credit must be given in these assessments to the one or two weeks' period which the fry need to travel from the spawning grounds to the coast.

Apparently, there are wide areas with two annual spawning seasons, and others with only one. Chanos spawns twice a year in the Java Sea, whilst there is only one spawning season in the Philippines and Taiwan. In India a second season seems to exist, although it is not as well-defined as in Indonesia. Since salinity and water temperature differ little in the Java and the Philippine Seas, other factors must be involved. Bunag (1951), reporting on his studies of the spawning habits, concludes : 'It appears that while the Philippine Chanos has one long resting period between spawning, the Indonesian Chanos has either two short resting periods or there are two races of Chanos in Indonesia.'

The available data concerning the occurrence of Chanos larvae (fry) in the various fishing areas is tabulated in Table VII.

Table VII

OCCURRENCE OF CHANOS LARVAE IN SHORE WATERS

Areas	First season From	First season To	Second season From	Second season To	Peak
India					
Gulf of Manaar	March	June			
Palk Strait	March	June	October	November 2/	May
Coromandel coast	April	June	September	November 2/	May
Malabar coast	May	June			
Indonesia					
Western section	March	June	August	September 3/	
Central section	March	May	September	December	April - October
Eastern section	March	May	September	December	April - October
Thailand	March continuing to December				
Vietnam	May	"	"	November	
Philippines	April	"	"	August	May
Taiwan	April	"	"	August	April - May
Fiji	February - March				

2/ Occasional reports.
3/ First and second season sometimes overlapping.

- Number of spawnings per year, frequency

Bunag (1951) studied the developing ovarial egg of Chanos from the Philippine Sea and concluded that the individual fish develops only one batch of eggs during the entire season; it probably spawns this batch at one time. Panikkar et al. (1952) investigated a mature female fish, caught in the Gulf of Manaar, India; in mid-October the fish had completely spent ovaries. No indications were present of protracted spawning, as no part of the ovary showed active growth of oocytes. Panikkar concluded: 'It is possible therefore, as far as individual fish are concerned, there is only one spawning during the year, but that the spawning period for the species is not limited to a very short term in terms of summer or autumn months.'

There are indications that schools of mature fish arriving at the spawning grounds at different times, perhaps in consecutive periods of high tidal levels, spawn independently of one another. This may explain the fact that batches of fry of uniform size can be observed in shore waters at intervals of weeks or even months.

- Spawning time of day

Delsman (1929) found that Chanos eggs from catches made in the morning hatched without exception during the evening of the same day. Taking into account the short incubation time of the pelagic eggs of related well-studied species, Delsman concluded that the eggs had been shed 24 hours prior to hatching. In a later publication (Delsman and Hardenberg, 1931) the authors state : 'Spawning takes place in the evening from 8 to 10 hours and the eggs develop in about 24 hours.'

- Induction of spawning, artificial fertilization

Little is known of the climatic and biotic factors inducing Chanos to spawn. In waters near the climatic margine of the species the rise of temperature in spring may be involved, since late onset of spring has a delaying effect on the appearance of fry on the coasts of Taiwan. In India the beginning of the fry season (March-April) coincides with the onset of spring, and the second period ends with the onset of winter. The water temperature in the Gulf of Manaar rises from 25.2°C in January to 29.8°C in April; it drops from 28.5°C in October to 26.2°C in December. In Indonesia the beginning of the spawning seasons coincides roughly with the change of the monsoons. On the other hand, lunar periodicity or perhaps only the high spring tide may also have an effect, since there is a marked increase of fry catches after periods of exceptionally high tidal levels.

All experiments to induce spawning in captivity have failed. Herre and Mendoza (1929) state : 'The fact that it never reaches maturity in large lakes is very strong presumptive evidence that it will not do so in shallow artificial ponds and that there are unknown factors essential to the development of gonads.' Later experiments revealed nothing that could throw new light on the problem. (See also 3.1.2).

3.1.7 Spawning grounds

- Coastal (surface, vegetation, shore, shoal, sand, shelter); bottom

The spawning grounds so far assessed are locations with clear shallow water above a

bottom of sand or corals and are situated at a distance of not more than 30 km from the shore. (See also 2.2 - Eggs).

Reijntjes (1926) reports spawning above submerged coral reefs at the south coast of Celebes, Indonesia. Philippine authors give as their opinion (unsubstantiated) that spawning takes place 'in quiet shallow sandy bays where the water is clear and the bottom consists of sand and corals.'

Delsman (1929) found his three batches of eggs floating at the surface in clear water of 20 to 40 m depth above a sandy bottom. In the two cases in which it was established, the salinity of the water was 32.0 and 32.8 °/oo. There was no floating or submerged vegetation. The shore areas in the vicinity consisted of sand.

Chacko (1950) reports seasonal occurrence of Chanos eggs in the waters around Krusadai Island, Gulf of Manaar, India. He caught his eggs in surface hauls. The waters in which the eggs were caught varied in depth from 2 to 20 m, the bottom being sand or coral; the salinity of the water fluctuated between 25.8 and 36.2 °/oo. The report does not mention abundant floating or submerged vegetation, but the neighbouring shores are sandy.

Jacob and Krishnamurthi (1948) report capture of fish ova, including those of Chanos, in the Ennore estuary, Chingleput district, Madras State, India. They state: 'These were surface collections made both at the bar and in the centre of the backwater.' This statement does not exclude the possibility of eggs being flushed over the bar by the incoming tide. If this is not the case, it would be the first report of proven spawning in waters within the coast line.

In the Progress Report of the Indian Council of Agricultural Research, Madras Rural Piscicultural Scheme (1951) reference is made to the occurrence of Chanos with mature gonads in Pulikat Lake and the adjoining coastal waters in the Nellore District, Madras State. In this area large Chanos are caught within a limit of 200 m from the beach. The Report states: 'The survey pointed to the fact that Chanos spawns ..... in the sea close to the shore in selected places. The presence of large Chanos within the lake indicates that spawners may enter even large backwaters and estuaries.'

3.1.8 Egg: structure, size, hatching type, parasites and predators

According to Delsman (1929), the yolk of the Chanos egg is segmented, but the segmentation is considerably finer than in the eggs of related clupeids. The segmentation is so fine that it is easily overlooked. The yolk is not quite colourless, as in the eggs of Clupeidae; it can be distinguished also by the larger diameter, the finer segmentation and the yellowish tinge of the yolk.

The diameter of the Chanos egg is 1.2 mm, while the mature ovarial egg measures 0.7 mm. Delsman states: 'Eggs of that size are too small to be demersal, they must be pelagical'; this conclusion has been confirmed by the capture of eggs in surface hauls. Chacko (1950) lists as chief character of the Chanos egg a yellowish frothy yolk and a diameter of 1.1 to 1.2 mm (Fig. 4a).

Chacko (1950) investigated the feeding habits of the principal species inhabiting the waters from which he obtained his pelagic Chanos eggs. He found miscellaneous fish ova in the stomach contents of Dorosoma chacunda, Dussumiera hasseltii, Leiognathus bindus and Rastrelliger kanagurta. These species are abundant in all areas where the occurrence of Chanos eggs has been reported, and the population density of most of them is considerably higher than that of Chanos. Egg predation is therefore likely.

No information is available on parasitic infection of eggs.

3.2 Larval history

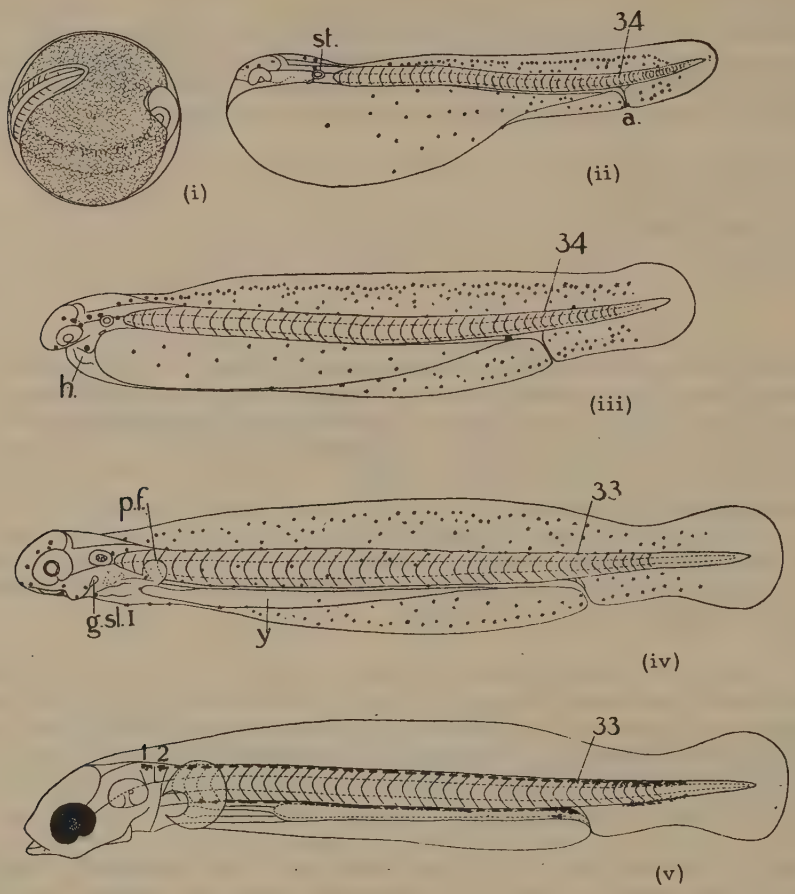
3.2.1 Account of embryonic and juvenile life (prelarva, larva, postlarva, juvenile)

According to Delsman (1929) the newly hatched larvae are of elongated shape with the anus situated well back; the tail is short. They can be distinguished from clupeid larvae by a great number of fine, black pigment cells, especially on the unpaired finfold, dorsally as well as ventrally, with the exception of the hindmost part of the tail. Pigment cells are present also on the yolk sack and on the embryo itself. The second characteristic of the newly hatched larvae is the arrangement of the muscle fibres in the myotomes : in clupeid larvae they show a crossed arrangement, whereas in Chanos larvae they are parallel to the longitudinal axis of the body, although they diverge slightly in the dorsal half of the myotome to the dorsal side and in the ventral half to the ventral side. The yolk tapers gradually into the gut; the head does not project in front of the yolk.

After 12 hours the yolk has been resorbed so that the head now projects beyond it. One day later only a small portion of the yolk remains and the under jaw is growing out; at this stage the pectoral fin appears. On the third morning after hatching the yolk has been resorbed and the eyes have become black. The number of myotomes in these larvae is 33 to 34; their length is about 5 mm. A single larva, similar in its characteristics to those observed after hatching in the laboratory, was caught by Delsman in a plankton catch.

The youngest larvae occurring in the commercial fry catches are about 10 mm long. The agreement in characters of the early larvae with these later stages is evident : in larvae of 10 mm length, the number of myotomes in front of the anus is 33; the muscle fibres run parallel to the longitudinal axis and there are two rows of black pigment spots; in larvae 12 to 13 mm long the number of myotomes decreases from 33 to 31 or 32, and the chromatophores gradually move from the dorsal edge of the myotomes to the lateral line where they are now arranged in a regular row; at 16 to 17 mm length the fin rays appear; there are now 30 myotomes in front of the anus, the height has increased, and the shape of the individual approaches the form of the adult fish; at the same time, black spots spread over the surface of the body (Fig. 4b).

The greater part of fry caught in commercial fry fisheries consists of individuals 11 to 13 mm long. When reared in aquaria on adequate planktonic food, such larvae grow to 20 mm length in about five weeks. At 20 mm length the fish have lost larval properties and resemble and behave as juvenile fish.



(i) Egg of Chanos chanos
(ii) Newly hatched larva; a. anus, st. statocyst
(iii) Larva of the next morning; h. heart
(iv) Larva of the second morning; g. sl. I. first gill split; p.f. pectoral fin; y. yolk
(v) Larva of the fourth morning

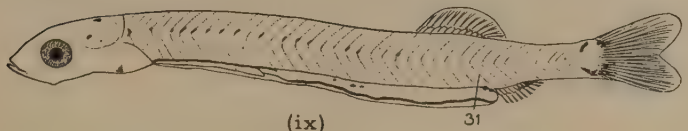
The above figures are enlarged 26 times.

Fig. 4(a)

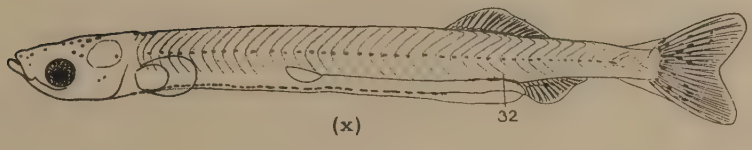
(vi)

(vii)

(viii)



(ix)



(x)

(vi) Pelagic larva of 6 mm
(vii) " " " 10 "
(viii) " " " 11 "
(ix) " " " 12 "
(x) Larva of fully 13 mm, showing the stage in which Chanos is caught along the coast.

The above figures are enlarged ten times.

Fig. 4(b)

- Feeding

During migration from the spawning ground to the beach the early larvae seem to consume very little food, if any at all. The intestinal tract of the translucent larvae caught in shore waters are always found empty; in captivity, however, and apparently in the second phase of their stay in littoral waters, the larvae 13 to 18 mm long feed on benthic, epiphytic and planktonic organism. The principal share of the food organisms is diatomaceous. When reared in aquaria, the larvae feed eagerly on the benthic diatoms, covering bottom and walls. Chacko (1942) reared larvae in captivity by feeding them with netted plankton.

In Indonesia the fry caught for commercial purposes are kept alive in containers for a period of two to four weeks and sometimes even longer. They are fed daily with uncooked, pounded rice, rice flour and occasionally with the cooked yolk of chicken egg. On this diet the larvae stay healthy and grow at approximately the same rate as they do in ponds.

In Taiwan, wheat flour is given to fry in ponds to increase the growth rate.

- Rates of: development and survival

The newly-hatched larvae have a length of 3 mm, they grow to 5 mm within three days and reach a length of 10 mm about ten days after hatching (see 3.2.1).

When larvae 10 to 13 mm long are caught in shore waters and stocked in ponds, the rate of growth is as indicated in the following two Tables.

Table VIII

AVERAGE GROWTH OF CHANOS IN PONDS WHEN STOCKED AT A RATE OF 10 - 100 FRY/m^2. Rabanal (1953)

Time	Average length (mm)	Average weight (g)
At stocking	12.9	0.005
End of first week	20.0	0.1
End of second week	29.0	0.22
End of third week	37.5	0.60
End of fourth week 4/	43.5	0.82
End of fifth week	46.1	0.97
End of sixth week	47.0	1.00
End of eighth week	52.4	1.42

4/ Retardation of development after the fourth week is due to crowding.

Table IX

AVERAGE GROWTH OF CHANOS WHEN STOCKED AT A RATE OF ONE FISH/m^2
Schuster (1952)

Time	Average length (mm)	Average weight (g)
At stocking	13	0.01
End of second week	28	0.20
End of fourth week	60	2.50
End of sixth week	110	17.00
End of eighth week	135	30.00

Unhampered growth can be expected only when the rate of stocking is kept below a rate of 10 fish/m^2. Densities of 30-50 fish/m^2, which are often applied in practice, result in delaying growth proportional to the restriction of food supply to the individual fish. A density of 100 fry/m^2 leads almost certainly to emaciation of stock through shortage of food.

Nothing is known about the rate of survival of Chanos in the sea. However, judging from the enormous disparity between the number of fry and the number of young fish in littoral waters, Chanos is probably liable to heavy predation by species abundant in the habitat where fry and juveniles occur (see also 3.1.8, and 3.2.1). Such predation does not exclude the possibility of a still unproven seaward migration of junior stages.

In pond culture the rate of survival is affected by five factors :

(a) Salinity

Chanos fry are resistant to a sudden transition from seawater to slightly brackish or freshwater, and vice versa. When the salinity of the water is higher than that of sea water, as often during stocking of ponds, partial or total mortality may result from the sudden transfer. The relation of mortality to varying salinities in pond water is shown below.

Table X

MORTALITY OF CHANOS FRY WITHIN FIVE DAYS AFTER TRANSFER FROM FRESHWATER INTO POND WATER WITH VARYING SALINITIES. Schuster (1952)

Salinity °/oo	0	10	20	30	40	50	60	70	80
Mortality %	8	5	5	5	6	100	100	100	100

(b) Condition of the subsoil

According to Schuster (1952) anaerobic processes develop when the mud of the deeper layers of the pond bed contains more than five per cent of undecayed vegetable matter. The processes result in formation of hydrogen sulphide and methane as well as in a withdrawal of dissolved oxygen from the water, sometimes leading to a total mortality of fry.

(c) Predation

Insufficient safeguarding of ponds against intrusion of predators (birds, snakes, fish) results in a low rate of survival (see 3.2.1 - Parasites and predators).

(d) Shortage of food

Inexpert treatment of the pond bed or inadequate depth of water may cause shortage of suitable food organisms or development of organisms of an unfavourable type. This condition, as well as relative shortage of food caused by overstocking, may affect the survival rate.

(e) Climatic conditions

Heavy rain or freshwater floods, which make the pond water turbid, are sometimes the cause of sudden mortality of fry.

In the five to 20 day-period between the capture of fry and the release in ponds, the rate of mortality fluctuates from two to 20 per cent according to the care with which they are handled.

A great body of practical information has been built up concerning the methods of treating young fish in ponds. Since a planned density of stocking can be maintained only when fish of at least fingerling size are used, raising of sufficient quantities of fingerlings is a factor of great concern to all fish culturists. Although the factors (a) to (d) mentioned above are in fact those responsible for the survival or otherwise of stock, in practice the rate of survival is dependent on the exactitude with which the nursery ponds are prepared; other factors are the punctuality with which the proper water level is maintained and the care with which the stock is protected against predation. The survival rate fluctuates within wide limits. In well managed fry farms, the rate of survival may be 80 per cent or even higher; the average lies between 30 and 50 per cent and in ponds operated by fish culturists 20 per cent is common. These data refer to conditions prevailing in the large pond systems in the Philippines and Indonesia; in the well-managed ponds of Taiwan, Chanos has a considerably higher chance of survival (Fig. 5).

- Periods of: development and survival

Approximately five to six weeks after hatching, i.e. about four weeks after release in ponds, a sudden increase of the urge for food is observed; the reasons for this are discussed in 3.5.3 - Physiology. When the ponds are stocked at a rate of more than 50 fish/m^2 this

Fig. 5 Pond for the rearing of Chanos larvae near Djakarta, Indonesia

often leads to serious competition for food. Retardation of growth and an increased rate of mortality may result.

- Parental care

No definite information is available, but the existence of any form of parental care is unlikely.

- Parasites and predators

Parasitic infection of fry has never been reported.

Restricted power of locomotion and instinctive schooling in loose formation make young Chanos an easy prey to any predator, as can be observed in pond culture practice.

The shore waters in which Chanos larvae occur are commonly populated with the predaceous species listed below:

Clupeiformes	:	Megalops cyprinoides
		Elops hawaiiensis
		Chirocentrus dorab
		Engraulis mystax
Percesoces	:	Sphyraena jello
		Polynemus heptadactylus
Ostariophysi	:	Plotosus canius
		Arius maculatus
		Ketengus typus
		Macrones gulio
Perciformes	:	Lates calcarifer
		Epinephelus tauvina
		Lutjanus chirtah
		Lactarius lactarius
		Sciaena alba
		Caranx calla
		Caranx hypos
		Therapon jarbus
Gobioformes	:	Glossogobius giurus
		Butis butis
Scombriformes	:	Cibium commersonii
		Rastrelliger kanagurta

A great part of these species is characteristic of the littoral, often estuarine, environments in which Chanos remains in juvenile stages. Chanos must compete with these species in the natural habitat, and must be protected against them when the environment is changed by human intervention. Rearing of Chanos involves a continuous struggle against predators. The large-mouthed larvae of Megalops cyprinoides immediately prey on Chanos when the larvae are mixed in the containers after capture. The young of predaceous fish come into the ponds with the sea water through the gates during filling, or they find their way through small leaks in the dikes. Two or three predators of more than 150 mm length in a nursery pond may considerably reduce the rate of survival of a stock of 10,000 fry. Fish culturists in Taiwan kill all animal life in a pond prior to the release of Chanos fry, by applying substances containing saponine.

Birds, water snakes, sea snakes, and frogs may also commit great depredations (see 3.3.4).

3.3 Adult history

3.3.1 Longevity

In large ponds in Java and Indonesia a few specimens of Chanos have been observed which, according to the reliable statement of the owner, were 12 years old. The fish had an individual weight estimated at 5,000 to 6,000 g. Six-year-old fish are mentioned by Chen (1952).

No information is available on the life span of Chanos in the sea.

3.3.2 Hardiness

Chanos excels in a great power of adaptability resulting in hardiness to survive under environmental conditions that would be disastrous to other species. The widespread utilization of Chanos for pond culture is founded on these characteristics, the most obvious of which are listed below.

Chanos is able to stay alive in water with a low oxygen content. One litre of water at 25°C is sufficient to keep 1,000 fry alive without need for artificial aeration. Suffocation of fingerlings or larger fish in ponds occurs only when the gillrakers become blocked by mud during fishing operations. When a pond is suddenly emptied, young fish may die from shock, but seldom from lack of oxygen.

Young and adult Chanos accommodate themselves easily to changes in salinity and, in an estuarine environment, adapt themselves to freshwater as well as to extraordinarily high salt contents when the rise in salinity is gradual. Sunier (1922) reports Chanos behaving perfectly normally in water with a salinity of 84.6 °/oo. Chanos stay alive in ponds where the high salt content has killed most other fish.

Chanos is able to stand sudden changes in diet. When the larvae are caught on the beaches of Indonesia and put into containers, they are suddenly subjected to a diet of pure carbohydrates (rice flour), whereas phytoplankton has so far been their natural food. In later stages the fish adapt themselves easily to feeding on more or less decayed filamentous algae

and submerged higher plants, although their natural foods would be mainly minute benthic and plankton organisms.

Chanos is able to stand temperatures considerably higher than those ever occurring in its naturalhabitat, the sea; they have been observed behaving in a normal manner in ponds and lagoons, the water of which had a temperature of 38°-41°C.

Although in origin a fish of the open sea, Chanos accommodates itself easily to crowding in restricted space. With just enough food for body maintenance, young Chanos can be kept in nursery ponds for months in a stunted condition. Larger fish are kept crowded in small ponds during the winter season (see 3.4.4).

3.3.3 Competitors

During all stages Chanos lives in competition with the various species of mullet (Mugil sp). This holds for open as well as for closed waters, since mullets are often kept in ponds with Chanos. Hiatt (1944) compares the food of Mugil cephalus and Chanos chanos in the lagoon like ponds in the Hawaiin Islands. He states : 'Analyses of 212 stomachs of mullet of various sizes show that they largely subsist on littoral diatoms and blue-green algae. In addition to sucking the littoral bottom-dwelling diatoms and other algae, mullet frequently browse on larger algae to secure minute epiphytic forms. Competition for food between mullet and milkfish is greater than hitherto supposed'.

All benthos and plankton feeding fish in ponds are potential competitors, since they seize a share of a restricted quantity of food. Serious competitors are : Mugil cephalus, Mugil dussumieri, Mugil seheli and Mugil vaigiensis, but also clupeids of the genus Pellona and perches of the family Leiognathidae, browse for food that could be used by Chanos.

Other forms of competition may occur as, for instance, for space on spawning grounds.

3.3.4 Predators

Predation is most serious in larval stages, the critical phase in the life history of Chanos, but small fish are still susceptible to predation, as has been widely proved by studies of the fish utilized in pond culture. In estuarine waters the carnivorous species grow more rapidly than Chanos and often cause a tremendous reduction of stock. As young Chanos keep together in schools even when chased by predators, depredation is also likely to be great in open waters. The following species are known to prey on juveniles up to a length of 100 mm :- in sea and estuarine waters : Lates calcarifer, Sphyraena jello, Chirocentrus dorab, and Polynemus heptadactylus; in slightly brackish and fresh water : Ophiocephalus striatus and Anguilla mauritiana.

Pugnacious predators of young Chanos are the water snakes Disteira ornata and Chersydrus granulatus and the frog Rana vittigera. Chanos swimming close to the water surface often become the prey of birds. Cormorants hunting for Chanos may dive in ponds, chase the fish into a corner and prey easily on the fish thus crowded. Shot guns, nets, traps, fireworks and other contraptions have to be used almost continuously to keep birds away from ponds with young Chanos. Kingfishers, terns, herons, eagles, and cormorants seem to develop a preference for feeding upon young Chanos.

3.3.5 Parasites and diseases

Very few cases of infection with parasites have been reported. Sunier (1922) found the upper part of the oesophagus of Chanos caught in the sea infested with nematodes of 7 mm length. Such parasites have never been found in pond-grown fish. Rabanal et al. (1951) state that external infestation of flat worm and crustacean parasites has been reported, but they conclude : 'Parasite infestation of bangos fry and fingerlings in the nurseries is rare and the possibility of death due to this cause may be remote'. Diseas caused by bacteria, fungi or viri has been observed only very occasionally. Rabanal et al. (1951) mention 'a case of epidemic diseas due to fin rot'. 'After strict disinfection and isolation of the case, recurrence of the disease has not been reported.' Schuster (1952) gives information about a condition resulting in a milky discolouration of the mucous membrane and the mucus. The diseased fish, almost blinded, swim with slackened movements in the ponds. The discolouration disappears after two to three days, while flaps of skin drop off later when regeneration of the diseased tissue has taken place. The condition, caused by a sudden drop in temperature of the pond water, does not result in mortality.

Freedom of an intensively cultivated fish from disease should be noted as an extraordinarily rare phenomenon. Schuster (1952) sees the non-occurrence of diseases and parasites as due to the continual renovation of stock, and to the disinfection which fish and ponds undergo when the salinity rises above 35 °/oo.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

Chanos in all phases of life seeks its food during the daytime. In littoral waters, schools of young Chanos have often been observed feeding on scum floating at the surface; adult Chanos have been seen doing the same in waters further offshore. Precise information is available about the manner of feeding during cultivation in ponds. Larvae, young, and adult fish often feed on matter floating on the water surface, sucking the materials in with a smacking noise. When feeding in this manner, the longitudinal axis of the body is at an angle of about 45°. The brighter the sun, the more benthic and planktonic organisms rise to the surface and consequently, the more fish resort to surface feeding. However, they exhibit no distinct preference for taking food from upper layers; while some of the fish are feeding close to the surface, others may be seen taking food from the bottom. Larvae and young fish often move into shallow water lays in search of food, provided the water is clear and the bottom covered with benthic micro-vegetation. Fish of more than 100 mm length do not move into water of less than 200 mm depth, perhaps because they fear predation by birds or perhaps because they cannot attain the proper position for feeding in shallow waters. When taking food from the bottom, the fish like to keep the body at an angle of about 30°, often bringing it into a sidelong position. In addition to floating and benthic food, the fish consume epiphytic organisms attached to roots of plants growing along the edges of the water.

In areas with a tropical climate, Chanos feeds with equal vigour at all seasons of the year. In subtropic areas, feeding is interrupted during the winter season while the fish are kept in small hibernation ponds; during that period, which usually stretches from October to March, the fish are fed with rice bran on warmer days; in cold weather the fish do not take food.

3.4.2 Food (type, volume)

- Chanos in the sea

Sunier (1922) examined the contents of the digestive tracts of Chanos 520-930 mm long, caught in littoral waters. Frequently he found the stomachs filled with Navicula- and Pleurosigma-like Diatomaceae, mostly typical benthic forms, which in the intestinal contents were strongly mixed with mineral particles originating from the sea bottom. Part of the food samples consisted of Chaetoceras, Bacteriastrum, Rhizosolenia, Thalassiotrix, Coscinodiscus, etc. and in a number of cases remains of multicellular plants, mainly Phaeophytae, were found. Sunier concludes : 'Chanos in sea takes off the upper layer of the sea bottom; they absorb chiefly great quantities of microscopic vegetable organisms and, together with these, Foraminifera, Lamellibranchiata, Gastropoda, and some (dead) bodies of Copepoda. If the fish come across multicellular vegetable organisms, they feed also on them.'

Chacko (1949) when investigating the food and feeding habits of the principal fishes of the Gulf of Manaar, India, found the stomachs of Chanos filled with Coscinodiscus, Fragilaria, Nitschia, Pleurosigma, Rhyzosolenia, Thalassiothrix, Trichodesmium, Oikopleura and Frittilaria; the faunistic elements consisted of copepods, larval bivalves, Leucifer, Mysis, Spiratella and occasional fish eggs and larvae. Chacko makes no mention of mineral particles or detritus in the intestinal contents. He classifies Chanos as a plankton feeder; he states that he has observed selective feeding on the Schizophycean, Trichodesmium.

Occasional selective feeding of large Chanos on mysids and, in aquaria, even on mosquito larvae, was observed by Schuster. For facultative feeding see 3.4 - Chanos in ponds.

- Chanos in estuarine waters

In the Hawaiian Archipelago, marine fish are reared in enclosures ('ponds') constructed by walling up the narrow entrance to a bay or inlet and providing sluice gates. Hiatt (1944) investigated the food cycles in these impounded waters, and has produced data giving evidence of the behaviour of Chanos in a biotope, closely resembling the natural habitat of the species. He concluded : 'Milkfish are herbivores and show no seasonal variations in food taken. Juvenile milkfish subsist almost entirely on minute algal types, while larger fish, although nearly half of the diet is diatomaceous, take a greater portion of larger algae.'

Hiatt's conclusion is supported by the data given in Table XI.

Discussing the food chains, Hiatt states : 'Phyto- and zooplankton are of little practical utility in the mullet and milkfish ponds. Neither of these species takes nourishment from this food source.'

In flagrant contradiction to Hiatt's findings are those of Chacko (1949), who investigated the feeding habits of young stages of estuarine fishes in the waters of Madras State, India. Chacko states : 'Chanos chanos, Ambassis ..... are almost entirely plankton feeders. The planktonic organisms which usually enter their diet are Hemidiscus, Navicula, Pleurosigma, Thallasiotrix, Coscinodiscus, Fragilaria, Nitschia, Rhizosolenia, Planktionella, Cymbella, Gomphonema, Pinnularia, Biddulphia, Ceratium, Peridinium, Tintinus, larval bi-valves, Diaptomus, Acartia, Evadne, Acetes, Mysis, Leucifer, etc.'

Table XI

DIETARY ITEMS OF *Chanos chanos* FROM ESTUARINE WATERS IN HAWAII
(Hiatt, 1944)

Food item	Percentage of stomachs containing the items	Percentage composition by volume
Contents of 38 stomachs of juvenile Chanos from 55 to 89 mm standard length		
Diatoms . . . . . Navicula, Cymbella, Melosira, Nitschia, Pleurosigma, Mastogloia, Coscinodiscus, Amphora, Surirella, Hyalodiscus	100	64
Blue-green algae . . . . . Oscillatoria, Merismopedia, Microcystis	47	17
Debris	82	13
Filamentous algae . . . . . Cladophora, Enteromorpha, Vaucheria, Spirogyra	58	3
Animal forms (Nematodes, crustacean ova)	26	2
Plant fragments (Batis maritima)	24	1
Contents of 17 stomachs of Chanos from 90 to 115 mm standard length		
Diatoms . . . . . Navicula, Nitschia, Amphora, Mastogloia, Pleurosigma, Surirella, Melosira, Coscinodiscus, Cymbella	100	48
Debris	100	32
Plant fragments	35	10
Filamentous algae . . . . . Cladophora, Spirogyra, Polisyphonia	29	7
Blue-green algae (Oscillatoria)	35	3
Animal forms (Nematodes)	6	trace
Contents of 59 stomachs of Chanos from 116 to 402 mm standard length		
Diatoms . . . . . Navicula, Nitschia, Amphora, Mastogloia, Pleurosigma, Surirella, Melosira, Cymbella	97	43
Filamentous algae . . . . . Vaucheria, Enteromorpha, Cladophora, Spirogyra, Acrochaetium	66	20
Plant fragments (Batis maritima)	85	14
Debris	97	11
Blue-green algae . . . . . Oscillatoria, Merismopedia	37	3
Foraminefera . . . . . Globigerina, Spiruloculina, Bolivinita, Pulvinulina	5	3
Nematodes	63	3
Copepods (Adults, larvae, ova)	58	3
Miscellaneous animal forms . . . . . Polychaets, ostracods	15	trace

The stomach contents of Chanos 14-16 mm in length, caught from the tidal creeks near Mandapam, South India, consisted mainly of Chlorococcales. Zooplanktonic elements were almost absent (Indo-Pacific Fisheries Council, 1953).

The contraversial results of the investigations of the feeding habits may be explained by divergent opinions about the origin of the food items and by the frequently observed tendency of Chanos to resort to facultative feeding. Many forms of diatoms found in the stomach contents are planktonic as well as benthic; Chanos may feed on plankton collected in midwater layers when no massed food supplies are available in benthic or surface layers. However, in reference to the classification of Chanos as a plankton feeder, the following statement of Sunier (1922) should be taken in consideration : 'I frequently found in the intestinal tract of Chanos caught in the sea large quantities of Pleurosigma-like and Navicula-like Naviculinae, that is to say diatoms, living at the sea bottom or on another firm substratum mixed with mineral particles. Many of the other organisms also found in the intestinal tract of sea Chanos in these cases such as Chaetoceras, Bacteriastrum, Rhizosolenia, Thalassiothrix, Coscinodiscus, Globigerina, Codonella, etc. belong indeed to the plankton, but it is well-known that (as is self evident) they or at least their dead bodies regularly get to the bottom of the (shallow) sea.'

- Chanos in ponds

There is evidence that cultivated Chanos resorts easily to facultative feeding. Differences in opinion about the principal food sources of Chanos in ponds are often due to generalization of the result of a local investigation.

In a region, ponds with more or less uniform salinity represent a biological complex with relatively similar biota. All algae in this complex are utilized as food by Chanos and in this wide range of nutritive elements, facultative feeding may not be evident to the casual observer. The fact that unicellular blue-green algae are the principal food element in one region does not exclude the possibility that Chanos would feed mainly on filamentous green algae in another, depending on the availability of food in bulk - even to a greater degree - on the physical condition of the principal food elements. Chanos evidently prefers soft and easily separable nutritive materials to hard, wiry, or leathery foods.

There is consensus of opinion about the food of Chanos ranging from 50 to 100 mm length. Gizzard and intestines are commonly found filled with blue-green algae, diatoms, protozoa and micro-crustaceans, mixed with a considerable share of mineral particles and organic detritus. Raban et al. state : 'The natural food of fry and fingerlings under cultivation is the brownish, greenish or yellowish crust of micro-benthic fauna and flora of the pond floor. The plant components are exemplified by various forms of bacteria, unicellular and filamentous blue-green algae, especially those belonging to the family Oscillatoriaceae, numerous diatoms and fragments of filamentous green algae. The animal components, which may be as equally important, consist of different forms of protozoa, copepods, ostracods, free-living flat worms, round worms and larval forms of mollusca and larger crustaceans.' To this should only be added that the benthic crust is often lifted from the pond bed by the oxygen formed during photosynthesis. The floating batches of benthic vegetation with the adherent soil particles are consumed by surface-feeding Chanos as completely as the benthic crust itself.

After the fingerling stage Chanos continues to consume benthic food until it reaches the adult stage, provided there are adequate quantities of this comparatively scarce food available. When benthic food becomes rare Chanos resorts to feeding on filamentous green algae fragmented and softened by decay; part of a fish stock may do this while a certain proportion of the diet is still provided by the benthic micro-vegetation. According to Schuster (1949) Chanos of less than 350 mm length is not able to handle wiry fresh Chlorophyceae in bulk; in aquaria the fish lose weight when exclusively fed with fresh filamentous Chlorophyceae of the Chaetomorpha type. However, even coarse forms of filamentous algae become suitable food for Chanos when they have lost elasticity and have become soft and easily macerated owing to age and partial decay.

Schuster (1949) investigated the stomach contents of Chanos 200-350 mm in size. One batch of his samples originated from ponds in which benthic vegetation dominated, the other came from ponds with a main vegetation of floating Chlorophyceae. His findings were as follows:

Table XII

FOOD ITEMS OF CHANOS OF 200 TO 350 mm LENGTH IN PONDS

Type of sample	Percentage composition of the dietary items				
	Cyanophyceae	Diatomeae	Chlorophyceae	Animal elem.	Detritus
Chanos from ponds with benthic vegetation	48.5	17.6	0.7	11.5	-
Chanos from ponds with Chlorophyceae	29.6	8.5	12.9	16.6	32.4

Schuster concludes that Chanos of maximal 350 mm length preferably feed on soft, benthic organisms; when these are insufficient, the fish eat decayed filamentous algae and higher aquatic plants. Animal organisms are consumed as incidental admixture to the vegetable main part of the diet. Fresh filamentous algae and plants do not appear as important food items because of the inability of the fish tohandle the elastic and coherent material. Operational procedures as employed by the fish farmers result in the domination of a certain type of algal vegetation and, in the end, a specific feeding pattern of the cultivated fish.

Chanos of more than 350 mm length still relish benthic organisms but resort gradually to consuming filamentous algae and plants. The greater width of the mouth and the greater strength make it possible for such fish to pull loose and consume batches of filamentous algae from the voluminous coherent masses often present in ponds.

The composition of the principal dietary items of Chanos is mentioned by Schuster (1949) :

Table XIII

COMPOSITION OF ALGAE PER 1,000 g WET WEIGHT

Composition	Cyanophyceae	Chaetomorpha	Enteromorpha
Water	829.0	951.2	937.3
Raw protein	16.5	22.8	12.7
Fat	3.9	9.6	2.4
Nitrogen-free organic material	13.7	2.7	13.3
Raw fibre	14.6	4.6	6.9
Ash	122.3	9.1	27.4

3.4.3 Relative and absolute growth patterns and rates

Scarcity of samples does not permit the drawing of reliable conclusions on size and age of Chanos in the sea. Evidently, the year classes mix because the adult specimens caught simultaneously differ widely in measurements. Efforts to distinguish the year classes by scale or otolith readings failed. Some data on absolute growth are given under 3.1.2.

Observations have been made in India by the Madras State Fisheries Department on the growth of Chanos originating from the two annual spawning seasons in neritic zones (Indo-Pacific Fisheries Council, 1953). The fish reach a size of : 110 mm after eight months, 180 mm after ten months, 200 mm after 12 months, and 250 mm after 15 months. These data seem to indicate that the rate of growth in open water is considerably lower than that in impounded water.

From the same source information is available on the growth rate in brackish water, so far not observed in other countries. In Madras there seems to be a significant variation in the growth pattern of fish of the April-May fry season and fish of the July-August season. The first-mentioned attain a length of 405-430 mm at the end of the first year, 480-508 mm at the end of the second, and 560-585 mm at the end of the third year. The July-August fry grow to a size of 305 mm in ten months and 380 mm in 22 months. For the rate of growth of Chanos in ponds, see 3.4.4.

3.4.4 Relation of growth to feeding, to other activities, and to environmental factors

During cultivation in ponds, the rate of growth is directly affected by the amount of food available to the individual fish. Absolute and relative growth in ponds are more or less a function of the stocking density; a high stocking density may result in a complete standstill or even in loss of body weight. Philippine fish culturists, carefully balancing the amount of food available to groups of juvenile fish, achieve a planned standstill of growth for about six months.

These stunted fish make normal relative growth when they are used later for stocking empty ponds. The effect of the stocking rate becomes evident from the following data published by Rabanal et al. (1952) :

Table XIV

RELATIVE GROWTH OF CHANOS AT DIFFERENT STOCKING RATES IN PONDS

Age	10 fry/ sq.m.	20/fry sq.m.	30 fry/ sq.m.	40 fry/ sq.m.	95 fry/ sq.m.	100 fry/ sq.m.
Weeks	Total length in mm					
Original stock	13.05	13.45	13.05	13.05	13.05	12.16
One week	26.21	18.86	25.38	26.19	23.64	16.32
Two weeks	38.38	29.82	34.63	34.52	29.67	24.84
Three weeks	56.78	40.97	46.14	45.38	40.35	28.28
Four weeks	70.47	50.17	47.71	46.82	42.30	33.78
Five weeks	79.02	52.35	51.76	49.67	44.66	36.86
Six weeks	76.24	55.01	53.34	51.15	45.36	36.59
Seven weeks	-	60.96	-	-	-	37.07
Eight weeks	82.50	62.11	54.70	55.91	48.25	41.86

When the stocking intensity is high, fish culturists try to prevent a decline in growth rate by supplying natural food, such as algae, from other ponds, or by adding commercial feeds. In Taiwan, 8,000 to 9,000 fish kept in a pond of 10,000/m^2 need supplements of 2,000 kg of rice bran, 500 kg of soybean cakes and 36 kg of peanut meal in order to grow at a maximum rate during the six months summer period.

The effect of temperature on the growth rate is clearly seen in the following comparison between the average weights of fish grown in countries where varied climatic conditions pertain.

Table XV

AVERAGE WEIGHT OF CHANOS IN PONDS

Country	Age of the fish stock			
	6 mo	8 mo	1 yr	2 yrs
	(g)			
Indonesia	250	350	750	1,500 - 2,000
Philippines	300	500	800	1,500 - 2,000
Taiwan	150	250	250	-

Space is one of the significant factors influencing the growth of Chanos in ponds. One hectare of fry pond with well-developed benthic algal vegetation is capable of supporting 300,000 to 500,000 fry or 30-50 fish/m^2. Moderate overstocking may be found in cases where it is desirable to inhibit and control growth of young fish intended as reserve for stocking ponds.

In rearing ponds, the density is reduced to 15,000 - 20,000 fish/ha (1.5 to 2 fish/m^2) and in the growing ponds the usual density is 500 - 1,500 fish/ha (one fish/6.6 to 20 m^2). Such stocking ensures growth at the highest rate possible under local circumstances, provided the water is kept at a level permitting the fish free access to all pond sections where benthic food is produced. Insufficient depth may hinder the fish from utilizing benthic food growing in shallow water. Production of benthic algae is at a maximum in water of 50-150 mm depth, but growing Chanos needs a water layer of at least 200 mm depth for undisturbed feeding (see 3.2.1 - Rates of : development and survival, and 3.4.1).

3.5 Behaviour

3.5.1 Migration and local movements

Present knowledge on the migration of Chanos can be summarized as follows :

The larvae migrate during a one to two weeks' period from the place of hatching to the coast; in areas with an indented beach formation they may enter bays, creeks, backwaters or estuaries, elsewhere they remain in the littoral or sublittoral neritic waters. The young fish leave the shore waters about four weeks later, probably to spread out in waters which produce benthic and planktonic food elements in adequate quantity. Juvenile Chanos, after having entered estuarine inland waters, may remain there for an uninterrupted period of four years before trying to return to sea. In February-March, mature fish in the entire area of distribution migrate landward to inshore waters for spawning, and it seems that they leave the coastal zone again immediately after the brief mating period. Mature Chanos, or perhaps only part of the stock in the Java Sea and probably also in South India, make a second coastward trip in October.

Little is known about the local movements of Chanos. Fry come into the zone extending from the water's edge to the seaward limit of the tide lands only during hours of high tidal levels. During egg they return to deeper water. Strong indications exist that all local movements of Chanos are tide-controlled. In ponds the fish show a very characteristic behaviour, unparalleled by other estuarine or marine pond fishes. On days at which high tidal levels can be expected the entire Chanos stock of a pond - or at least the fish exceeding a length of 150 mm - become very excited. Hours before the advancing tide has reached the pond, the fish swim close to the surface of the water, all in the same direction, circling the pond time after time. When water is let into the pond the fish swim against the current and accumulate as if hypnotized in front of the screen which closes off the gate. Efforts to swim against the current are so violent that many fish wound themselves by pushing the snout against the screen. The fish become quiet again some hours later but adopt the same attitude the next day if the tide again reaches a high level. During such periods of unrest the fish take hardly any food. If the gate of a pond were opened during flood hours the entire Chanos stock would migrate seaward as if attracted by magnetic force. The movement of the fish when they turn round in the pond in expectation of the spring level is similar in nature to that of fry, which continually swim round in a vessel or container.

3.5.2 Schooling

Observation of Chanos in all phases of life shows that the typical schooling instinct of clupeoids is never strong. Very disciplined schooling is demonstrated in larval stages. No matter how many larvae are kept in a container, all turn round in the same direction, swimming close to the wall of the vessel. The regular movement is interrupted only when artificial food is given to the fish. In about 80 per cent of the observations the fish swim in a clockwise direction. Healthy larvae react promptly and all in the same manner when the container is touched : they dive to the bottom but continue to move. Schooling discontinues only when the fish are sick or weak.

In ponds, juvenile and half-grown fish form schools, young fish in batches of hundreds, the elder in tens. During the night the entire Chanos stock accumulates in the deepest section of the pond system and stays close to the bottom almost motionless.

Small schools of adult Chanos have been observed in the sea (see 2.2.1 - Adults).

3.5.3 Reproductive habits

(See 3.1.1, 3.1.3, 3.1.4 and 3.1.6 - Number of spawnings per year, frequency - Spawning time of day - Induction of spawning, artificial fertilization).

- Physiology

Hiatt (1944) found heteronomous growth of the intestine in juveniles. He states : 'An intestinal length - standard length ratio between 2.3 : 1 and 3.8 : 1 obtains for fish between 55 and 90 millimetres standard length. During this period of growth, a fish increases its standard length about 80 per cent while the intestinal length undergoes an increment of approximately 100 per cent. The intestine of milkfish between 90 and 115 millimetres standard length increases approximately 200 per cent. The intestinal length-standard length-ratio mounts from about 3.5 : 1 for fish of 90 mm length to approximately 7.2 1 for fish which attained a standard length of 115 millimetres. Intestinal growth, relative to increase in standard length, is retarded in fish above 115 millimetres.' The author concludes : 'Rapid acceleration of intestinal growth and the maintenance thereafter of an increased intestinal length may be a direct result of the digestive requirements associated with an increased mass of larger plant foods eaten by fish above 90 millimetres.'

Schuster (1949) investigated the intestinal length of Chanos in ponds. He found individual variation of the intestinal length-standard length-ratio from 2.8 : 1 to 12.8 : 1. The first series of his samples comprised fish originating from a pond with a dominating vegetation of benthic Cyanophyceae; the second series comprised specimens from a pond containing Chlorophyceae. The fish of the first series had a ratio of 7.9 : 1, the second series one of 5.7 : 1. The author concludes that predilective feeding on soft, mechanically easily digestible foods results in accelerated growth of the digestive system as reflected in the elongation of the intestine. An intestinal length-standard length-ratio exceeding 10 : 1 has not yet been reported from other species, even in individual cases. The author feels that the widespread utilization of Chanos as pond fish can be explained by the ability of the species to adjust morphologically to the environment.

Viswanathan and Tampi (1952) investigated the oxygen consumption of Chanos fry when kept in containers. Using as a basis the factor ml initial oxygen per g of fish, the authors conclude that the mortality of fry in hard freshwater is relatively less than in sea water, while under conditions of asphyxiation the survival time is not affected to any significant extent by the salinity of the medium. Equations have been derived in interrelating length, weight and oxygen consumption for use in the transport of live fish (Indo-Pacific Fisheries Council, 1953).

In the Central Marine Fisheries Research Station, Mandapam, India, a study was made of the adaptive responses of Chanos. Panikkar et al. (1952) investigated adaption to salinity and temperature, and Viswanathan and Tampi (1952) to the content of dissolved oxygen. An abstract of the results of these investigations was published by the Indo-Pacific Fisheries Council (1953).

A detailed study of the structure and function of the pituitary and tyroid gland of Chanos was made by Tampi (1953).

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex ratio

A sample of pond fish, which Schuster investigated for intestinal length, comprised 68 males and 84 females with gonads all rudimentarily developed. No data are available about the sex ratio of Chanos in the sea.

4.1.2 Age composition

No information is available on Chanos in open water. Some data on cultivated stock are given under 3.4 and 5.6.

4.2 Size and density

4.2.3 Average density

The average density at which Chanos is grown in ponds fluctuates widely within the limits set by productivity and operational systems. The ranges of density, established by interpolation of the available data, are as follows :

Table XVI

CHANOS IN PONDS
DENSITY AT ONE POINT OF TIME, NUMBER OF FISH PER 100 m^2

Country	Fry 10-15 mm	Fingerlings 15-150 mm	Juveniles 150-500 mm
Indonesia	1,000 - 5,000	30 - 50	3 - 10
Philippines	3,000 - 5,000	150 - 180	10 - 15
Taiwan	50 - 90	50 - 90	30 - 40

4.4 Mortality, morbidity

4.4.1 Rates of mortality

No data available about mortality of Chanos in the sea.

The rates of mortality of cultivated fish are :

fry : 2-25 per cent during shipment in containers in a two to three weeks period;

fingerlings : 50-70 per cent during raising from fry to fingerling stage in a six to eight weeks period;

juveniles : 20-30 per cent during raising of fingerlings to fish of maximal 500 g weight in a period of eight to ten months.

See also 3.2.1 - Rates of : development and survival.

These figures represent the averages as found in large-scale fish culture in the Philippines and Indonesia. In Taiwan, improved operational systems reduce the rate of mortality to about 20 per cent in rearing from fry to fish of 150 g weight and to 30 per cent in rearing of fish to 200-300 g weight (Chen, 1952).

4.4.2 Factors or conditions affecting mortality .

For conditions in fish farming see 3.2 - Rates of : development and survival - Parasites and predators, and 3.3.2, 3.3.4 and 3.3.5.

4.5 Dynamics of population

4.6 Relation of population to community and ecosystem, biological production, etc.

In the abundant assemblage of approximately 200 species competing for food in the littoral and estuarine zones of the Indo-Pacific waters, only the Mugilidae and Chanos chanos as a single representative of the Clupeiformes depend almost exclusively on the benthic biota and on plankton. Chanos has virtually no competitors for the larger benthos since the amount of this food taken by other littoral species is insignificant. Adult Chanos is the only significant consumer of filamentous and tubiform algae. In open water, in an environment possessing many carnivores, predation and not competition for food is most likely the factor limiting the abundance of Chanos (Hiatt, 1944).

Because Chanos feeds directly on primary producers (algae) it could be expected a priori to have a high economic efficiency, and when the fish is raised in ponds where the food plants are abundant and anemies largely excluded, such expectation is realized. An annual production of 500-1,000 kg/ha is a substantial yield, considering that it has resulted entirely from food grown without the addition of fertilizers (Frey, 1947).

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

Adult Chanos are commonly caught during operations directed at the capture of other species; Chanos contributes a minor share of the catch. Single fish are caught in stake traps as used everywhere in the area of distribution for the shore fisheries. Here and there a large Chanos is caught in a liftnet or a seine at less than 50 m distance from the beach. A school of large Chanos offshore is located from a boat by observation of the dorsal fins rising above the water; a harpoon or a spear may be used to catch a fish. There is also a report from the Philippines about landings of adult Chanos caught by using explosives.

The various means of catching Chanos fry are discussed below. Scoopnets are used which consist of two crossed poles and a piece of coarse cloth which forms a bag. The shorter ends of the poles serve as handles; with these, the fisherman pushes the net forward. The wideth of the net at the front is 1 to 2 m; the length of the poles varies from 1 to 3 m. In Indonesia small scoopnets made of rope and sliced palm-leaves or grass are used to collect fry that have sought shelter in sausage-like rolls or garlands set out by the fishermen. The rolls are kept floating during flood tide along poles driven into the sea bottom. In Taiwan the fisherman wades chest-high in the water or swims with a rubber tude around his waist, pushing the net in front of him. In the Philippines a scoopnet with 3 m-long poles is operated by two fishermen. Dragnets equipped with floats and sinkers are used in Taiwan. The net, 5 to 10 m long, is towed by two ropes, one attached to a manned raft, the other handled by a man walking along the beach. When there is a tidal current along the coast the net is sometimes used in a fixed position. In the Philippines two fishermen drag a net 5 m long along the shore, and stationary traps are used for capture of fry in creeks or in the mouths of small rivers. Fences or wings of plaited bamboo lead the fry to a 2 m long hoopnet held in position by poles driven into the bottom of the creek. The hoops are covered with coarse cloth.

Chanos are caught fron ponds with gillnets, seines and castnets. For the capture of large quantities of fish the ponds are partly drained and sea water is let in during rising tide. The fish swim against the current, accumulate in the sluice gate and can be scooped up for selection or capture (Figs. 6, 7 and 8).

5.1.2 Fishing boats

No specific vessels are used for Chanos fisheries.

5.2 Fishing areas

There are no areas in which a specific fishery for adult Chanos is in operation. For fry fisheries see 2.2 - Young.

5.2.1 General geographic distribution

See 2.2 - Larval stages - Young.

Fig. 6 Capture of Chanos larvae on Madura Island, Indonesia

Fig. 7 Capture of Chanos larvae in East Java, Indonesia

Fig. 8 Capture of fish in a Chanos pond near Djakarta, Indonesia

5.2.2 Geographical ranges (latitudes, distances from coast, etc.)

See 2.2.

5.2.3 Depth ranges

Adults and junior stages are caught in shallow water.

5.3 Fishing seasons

5.3.1 General pattern of fishing season

Adults are caught along the coasts approximately one month before the beginning of the fry season. For limits of fry season see 3.1.6 - Spawning seasons (beginning, end, peak).

5.3.2 Duration of fishing season

See 3.1.6 - Spawning seasons (beginning, end, peak).

5.3.3 Dates of beginning, peak and end of season

See 3.1.6 - Spawning seasons (beginning, end, peak).

5.3.5 Factors affecting fishing season

In the opinion of most fishermen the quarter from which the wind blows has great influence on the quantity of fry occurring along the coasts; in general, catches are good when the direction of the wind is parallel to the coast, and they are markedly low when the wind blows straight to or from the coast. Soft rain seems to favour the occurrence of fry; stormy weather makes them disappear. In all areas the greatest catches are made during the periods of high tidal levels at full and new moon.

5.4 Fishing operations and results

5.4.1 Effort and intensity

Fry fisheries vary in effort and intensity according to the rate of extension of pond culture in the respective areas. Usually, operators of fish ponds are willing to pay the equivalent of US $1 to $6 per 1,000 fry; since prices rise rapidly when the supply is low, fry are now shipped over distances of more than 1,000 km to the distribution centres. Demand being often greater than supply, the intensity of fishing operations along well-producing beaches often reaches the point where every available local hand is engaged in the operation; scoopnet fisheries are often operated by women and children.

A day's catch fluctuates from 25 to 1,000 fry; at vantage points fry taps may deliver up to 20,000 fry a day. In scoopnet fisheries the intensity may be such that a stretch of beach is fished by as many persons as can handle the gear without hindering others. On the other hand, wide stretches of beach at a certain distance from the pond centres are not fished at all, and the possibility of transferring fry from one country to another is still being investigated.

5.4.2 Selectivity

The fine-meshed nets used to catch Chanos larvae are not selective. The catches actually represent the entire animal assemblage of the waters in close vicinity to the coast. In order to select the Chanos larvae, the fishermen transfers the catch to a container from which he selects the useful part with a shell or cup. In the catches, Chanos larvae are commonly intermixed with Mugil, Megalops, Elops, Dorosoma and Stolephorus larvae; sometimes the useful share of the catch is not more than one per cent.

5.4.3 Catches

In India, Ceylon, Thailand, Taiwan and the Philippines, the annual catches of adult Chanos vary from a few stray specimens to some hundreds of fish; even the commercial and subsistence fisheries of the many islands of Indonesia do not produce more than approximately 1,000 to 2,000 fish a year. Chanos is relatively common in Polynesia, but there are no reports of bulk landings.

The average quantity of fry caught in the various countries is as follows :

Table XVII

ESTIMATES OF FRY CATCHES (millions)

Country	Total annual catch	Average annual catch	Quantity required for average stocking
Taiwan	20-100	45	80
Philippines	300-500	350	425
Indonesia	150-300	200	275

Some ten thousands of fry and fingerlings are caught every year in India for transfer to lotic waters in the State of Madras, and some thousands in Hawaii, Thailand, and Fiji for transfer to brackish water ponds.

5.5 Fisheries management and regulations

Many years ago the Governments of Indonesia and the Philippines started programmes of research and management, but the rate of progress has been affected by varying degrees of financial support, discontinuity of personnel, and the small number of able instructors.

In Indonesia, management of Chanos culture was initiated in 1864 when the Superintendent of Culture, P.W.A. van Spall, summarized the results of his investigations in a treatise on the

management of Chanos ponds; it was accompanied by excellent instructions for the Javanese supervisors of ponds. An Inland Fisheries Service was established in 1916, and extension work started eight years later with Indonesian staff trained at the Agricultural College at Bogor. In the years between 1928 and 1942 a scientific basis was laid for effective management of Chanos culture, resulting in the development of technical irrigation of large pond systems, improvement of fry-rearing methods, and application of organic fertilization. Furthermore, the marketing of the products of pond culture was reorganized and modernized.

At present, the workers of the Laboratory for Inland Fisheries at Bogor are in charge of solving special biological problems in Chanos culture, whilst management and extension work are entrusted to the branches of the Inland Fisheries Service which have been established in most provinces.

In the Philippines, A.W. Herre, Chief of the Division of Fishes of the Bureau of Science from 1920 to 1928, instigated better management of the fish pond industry. He built up a staff of Philippine workers trained locally or in the United States; this group was later incorporated in the Bureau of Fisheries. An experimental station for the study of Chanos culture was established near Manila and, in extension work, efforts were made to replace empirical practices by scientific and more economical methods. At present the staff of the Bureau of Fisheries handles scientific as well as managerial aspects of Chanos culture.

In India, the Central Marine Fisheries Station at Mandapam undertakes investigations on the biology and physiology of Chanos, while the Fisheries Departments of the various States are in charge of fish culture and management extension schemes.

In Thailand, the Fisheries Department is engaged in a research and experiment program for the production of cultivation of Chanos in ponds.

In Taiwan, the Chinese-American Joint Commission on Rurual Development is investigating and improving fish cultural methods.

The Food and Agricultural Organization of the United Nations appreciates the great potentialities which the area has for the culture of brackish water fish and has, therefore, sponsored training courses as a means of helping to overcome the shortage of trained personnel. This lack is commonly recognized as the main reason for slow progress. As a result of the Indo-Pacific Fisheries Council resolution adopted in 1950 - that courses should be organized to train fish culturists - FAO sponsored a Seminar on Brackish Water Fish Culture; this was held in Djakarta, Indonesia, from 11 April to 29 May 1951 under the supervision of the IPFC. Lectures organized by the Government of Indonesia were attended by 14 students. In 1951, the IPFC adopted a recommendation to initiate training for Government officers in fresh and brackish water cultural practices. FAO again responded by sponsoring a second training course. Eighteen participants attended this course, which was held from 1 May to 15 June, 1952, and which also took place in Djakarta.

When the IPFC asked that a third course be held in 1954, FAO organized an international inland fisheries training centre at Bogor, from 31 October to 10 December, 1955. During this course a staff of eight foreign and eight Indonesian lecturers gave training to 20 participants, all Government fisheries officers from the following countries : Australia, Burma, Ceylon, Hong Kong, Indonesia, North Borneo, Philippines, Sarawak, Thailand, and the United Kingdom.

all three training courses Chanos culture was one of the principal subjects.

Nowhere in the Indo-Pacific area are Chanos fisheries or Chanos culture regulated, nor does there seem to be any need for restrictions since catches do not show any decline; on the contrary, potential fishing grounds are still left unexploited.

Certain regulations exist in the Philippines for the capture of fry, but they are more of a fiscal than a managerial nature; each season coastal municipalities lease the shore areas where fry can be caught to the highest bidder, without establishing any limit for the catches. In the Philippines, as also in Indonesia and Taiwan, Chanos ponds are taxed by the Government.

5.6 Fish farming, transplanting and other intervention

Estuarine waters of virtually every shape and type serve as a temporary habitat to Chanos who have entered from the sea during juvenile stages. Such waters attain the character of primitive ponds when the apertures are closed off, but even when provided with sluice gates such waters do not reach the criterion of ponds in sensu stricto, viz., complete control of water supply and possibility of complete removal of water and stock.

'Primitive' Chanos ponds are in operation in many countries. Those of the Hawaiin Islands are well-known and cover a surface of about 850 ha. Furthermore, there are systems of primitive ponds along the coast of North and South Vietnam, and a well-stocked area of ponds in the Rewa delta, and in Fiji; the practice of constructing Chanos ponds is known also in the Gilbert Islands and in certain islands of the Lau group.

Chanos culture has reached its highest level within the sinomalayan cultural sphere. It is an ancient industry, based on technical skill in pond construction and an almost instinctive understanding of the physiological requirements of the cultivated fish. In the Philippines, Indonesia and Taiwan, it has been developed over many years. Reference to the latest publications shows that Chanos culture in these countries has reached the extent indicated in the Table below :

Table XVIII

TOTAL AREA OF CHANOS PONDS (ha)

Country	Area	Area of estuarine lands suitable for conversion into ponds
Philippines	88, 000	430, 000
Indonesia	128, 000	6, 000, 000
Taiwan	13, 000	

Recent rapid increases of the pond areas is reported from all countries mentioned above. Experiments with Chanos culture in estuarine waters are in progress in India, Thailand, Fiji, and Samoa.

In Chanos culture, as it is applied at present, ponds are constructed by surrounding an estuarine area with embankments or dikes; this is done by dividing the impounded land into manageable sections and by providing the system with a main sluice and connecting sluice gates. Ten hectares of land subdivided into four or five sections can be efficiently irrigated from one sluice, provided the site is in direct connection with the sea or an estuarine system (Figs. 9, 10 and 11).

Managerial operations in Chanos culture can be classified by relating them to the three phases of the productive process, i.e. (i) capture, selection, and transportation of stocking material; (ii) raising fry to fingerlings; (iii) rearing fingerlings to fish of marketable size.

For data on the collection and transportation of fry, see 2.2.1 - Larval stages; 3.1.5; 3.1.6 - Spawning seasons (beginning, end, peak); 3.2.1 - Feeding; Rates of: development and survival; Parasites and predators; 5.1.1, and 5.4.3.

Raising fingerlings is either part of the process of raising fish to marketable size, i.e. to 500-600 g individual weight, or it is carried out as a specific operation by people specializing in the work. The basic feature in raising fingerlings is the great care given to the physical, chemical, and biological components of the pond environment; the aim is to assure that the rate of survival exceeds the minimum of 50 per cent required for economic variability. Preparation and management of nursery ponds require a skill attainable only by long experience or by a thorough study and understanding of the factors involved; a fish culture project often fails because of inexpert handling of this phase.

Prior to being stocked, well-operated nursery ponds should be flushed several times during high tidal levels to wash out old salt accumulations; then the ponds are drained and kept dry for days or weeks until the upper layer of the pond bed has attained the structure of mineralized soil. Salt water or brackish water is admitted then to a depth of 3 to 10 cm and the water kept at this level by refilling the pond until a dense layer of benthic algae and associated organims covers the bottom. In a warm climate this stage may be reached after five to 15 days. In a subtropical climate the algal mat or crust needs up to eight weeks to reach sufficient density. The water used to fill the ponds is carefully filtered to prevent the entrance of browsing animals that could disturb the algal layers.

Ponds with a normal development of benthic micro-organisms can support 30 to 50 fry/m^2. When algal growth is sustained by regular freshening of the water the fish should grow at a rate of more than 1 mm a day and should reach a length of 70-100 mm after six to eight weeks in the nursery ponds. The mortality rate should be less than 50 per cent, but in general practice it may amount to 70 per cent. In experimental ponds or specialized fry farms, considerably higher survival rates are attained.

The fingerlings are transferred to rearing or growing ponds where they are usually stocked at a rate of about 500/ha in Indonesia, 1,000/ha in the Philippines, and 3,000/ha in Taiwan. The process of rearing fish of an individual weight of about 500 g takes six to eight months, the rate of growth and total production depending on the natural productivity of the pond, the density of stocking, the fertilization, and the amount of artificial food given.

Fig. 9 Chanos ponds near Djakarta, Indonesia

Fig. 10 Airial view of Chanos ponds in East Java, Indonesia

Fig. 11 Marketing of pond-grown Chanos in Indonesia

The average production per hectare per annum is 300 kg in Indonesia, 350 kg in the Philippines, and about 2,000 kg in Taiwan, where heavy fertilization and artificial feeding is applied. By keeping the size classes in separate sections of the pond system, one, two or three crops per year may be produced. Average mortality during the rearing of fingerlings to fish of marketable size should not exceed 25 per cent.

Juvenile Chanos, varying from 15 to 25 mm in size, are used in the State of Madras, India, to stock freshwater ponds, tanks and irrigation reservoirs. More than 100,000 fry are collected every year for transportation into the interior of the country. The time-consuming process of gradually reducing the salinity of the water prior to shipment has been abandonned; the fish are now transported in slightly brackish water. The fish are stocked at a density considerably lower than that used for ponds in countries with an indigenous Chanos culture, and reach a size of 350 mm at the end of the first year.

A new development of Chanos culture in Indonesia is rearing in ponds into which sewage water is admitted at a rate of one part sewage to two parts river water. Chanos fry are transported to inland ponds in vessels filled with slightly brackish water; the nursery ponds are stocked at a rate of 500/m^2. When the fish attain a length of 100 mm they are transported to larger ponds where they reach a size of 300-500 mm after three to four months. The production per hectare per annum is 5,000 kg, equal to the production of common carp, but slightly inferior to that of Tilapia.

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